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Assessment of the Voisey Unit Arctic Charr Population in 1987

by

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Abstract

Reported landings of Arctic charr from the Voisey assessment unit totaled 21 t in 1987 and exceeded the total allowable catch of 17 t by 25%. This catch represented 22% of the total catch of Arctic charr from the Nain Fishing Region in 1987. Landings were 28% higher than in 1986, while effort increased by 23%. Likelihood ratio statistics were used to examine temporal variation in the size composition of the catches from 1980 to 1987. Significant differences were found among years and specific time periods within the fishing season. Mean length is lower in recent years but has not declined consistently over time. The 1977-79 year-classes represented 78% of the catch in 1987. A sequential population analysis was carried out on catch-at-age data from 1977 to 1987 and suggested a reference level catch in 1988 from 14 to 17 t.

RESUME

Les débarquements d'omble chevalier enregistrés pour l'unité d'évaluation de la Voisey ont totalisé 21 t en 1987 et ont dépassé de 25 % le TPA fixé à 17 t. Ces captures représentaient 22 % du total des prises d'omble chevalier de la région de pêche de la Nain en 1987. Les débarquements étaient de 28 % supérieurs à ceux de 1986, tandis que l'effort a augmenté de 23 %. Les statistiques sur le rapport de vraisemblance ont servi à examiner la variation temporelle dans la composition par taille des captures entre 1980 et 1987. Des différences significatives ont été relevées d'une année à l'autre et entre des périodes particulières à l'intérieur de la saison de pêche. La longueur moyenne est inférieure ces dernières années, mais n'a pas baissé de façon constante avec le temps. Les classes d'âges de 1977-1979 représentaient 78 % des captures en 1987. Une analyse séquentielle de population portant sur les données concernant l'âge à la capture de 1977 à 1987 indiquerait un niveau de référence des prises de 14 à 17 t pour 1988.

Introduction

Catch statistics from the Voisey assessment unit, made up of the Voisey and Antons subareas (Fig. 1), have been available since 1974. It was first assessed as a single unit in 1985. Annual landings have ranged from a low of 4 t in 1975 to 41 t in 1979 with an average of 22 t over the 14-year period. From 1977 to 1987, landings from this unit have represented 15% of the total commercial production from the Nain Fishing Region. In 1987, 22% of the commercial landings came from the Voisey unit. The recommended total allowable catch (TAC) in 1987 was 17 t.

This paper summarizes the results of the 1987 fishery and provides a forecast of available harvest, or reference level catch, for 1988.

Assessment

Catch and effort data

Catch and effort data for the Voisey assessment unit are summarized in Table 1 for 1974-87. Landings in 1987 totaled 21 t, an increase of 28% from 1986 and exceeded the TAC by 25%. Fifty-nine percent of the catch was taken in the Voisey Bay subarea. Effort increased by 23% while catch per unit effort was 3% higher than the previous year. The Voisey unit was closed to commercial fishing July 27, 1987, although 97% of the TAC had been taken by the week ending July 15, 1987.

Size distribution of commercial landings

Since 1980, approximately 28,000 fish have been sampled from the Voisey assessment unit to obtain information on the size distribution of the commercial landings. The length-frequency data were examined to determine any heterogeneity of samples which could be related to the effect of commercial exploitation on the stock. Likelihood ratio statistics were used to examine temporal variation in the size distributions.

Arctic charr were measured for fork length and recorded in two-centimeter intervals. The smallest fish measured over the past eight years (1980-87) were in the 32 cm interval (32.0-33.9 cm), while the largest were from the 74 cm grouping. Analyses, however, were conducted on truncated data which excluded fish less than 42 cm in size and those fish which were in size categories 66 cm or higher. In total, 98.8% of all fish measured were within the 42-64 cm length intervals. The truncation also removed the possibility of obtaining any zero values for expected cell counts in the analyses.

There was a highly significant difference in the size distribution of catches among years ($G = 1178$, $df = 77$, $P = 0.000$, $N = 28,037$). As indicated in Table 2, modal size has changed from the 52 and 54 cm intervals in 1980 and 1981 to the 50 cm interval during the past five years. Mean lengths are also summarized in Table 2. Mean length in recent years is lower, but has not decreased consistently. Similar to the analyses for the Nain unit catches

(Dempson 1988), the fishing season was stratified into four time periods: June 15-July 14, July 15-July 31, August 1-15, and August 16 to the end of the fishing season. There is a difference in the size distribution among time period, and within individual time periods the size distribution differs between years (Table 3). There is a tendency for mean length of catches to decrease as the fishing season progresses for this assessment unit also (Table 4).

Cohort analyses

Numbers at age were available since 1977 and are summarized in Table 5. Data were derived from annual commercial sampling programs. Mean age of the catch has ranged from 8.2 to 9.1 years with no apparent increasing or decreasing trend. On average, 70% of the catch is made up of three age-classes of fish represented by 8-, 9-, and 10-year-olds. In contrast, these age classes represent about 60% of the catch in the Nain assessment unit (Dempson 1988). The 1977-79 year-classes made up 78% of the catch in 1987.

Weights at age were calculated from commercial samples obtained from 1977 to 1987. Gutted head-on weights were converted to whole weights using the conversion factor of 1.22 (Dempson 1984). For yield-per-recruit analysis, mean weight at age for the period 1977-79 was used as in past assessments. For stock projections, mean weight at age for the period 1984-87 was used (Table 6).

Total mortality ($\bar{z}$) was calculated using the Paloheimo method (Ricker 1975) and the average value for all years (1977-78 to 1986-87) was 0.81. The average $\bar{z}$ for the last five years was 0.83. Assuming a natural mortality rate of 0.2 results in an estimate of fishing mortality of about 0.62. An estimate of total mortality derived from a catch curve using catch per unit effort at age data from 1985 to 1987 similarly gave a value of $\bar{z}$ of 0.81.

An independent estimate of exploitation and fishing mortality, as derived from tag recaptures, was obtained for the first time for this assessment unit in 1987 where:

$$\mu = 1 - e^{-F} \text{ (Ricker 1975).}$$

Assuming a value of 10% for an estimate of tagging mortality, tag loss, and non-reporting of tags results in a value of μ of

$$\mu = \frac{72}{148} = 0.486,$$

with a rate of fishing mortality of 0.67 (95% CL = 0.49 - 0.95).

An initial cohort analysis was run using partial recruitment values and terminal fishing mortality ($F_T = 0.5$) from last year's assessment (Dempson and LeDrew 1987). An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group (F_B) (Rivard 1982). Following this, partial recruitment rates were calculated using the historical averaging method from the matirx of fishing mortality values from 1981 to 1985. These values were

then applied to the initial terminal fishing mortality rate and the procedure repeated until the partial recruitment values stabilized (Table 6).

Yield per recruit was calculated by the method of Thompson and Bell (Ricker 1975) using partial recruitment rates and mean weight at age. $F_{0.1}$ was 0.40 at a yield per recruit of 1.08 kg.

Cohort analyses were run using a range of terminal fishing mortality values from 0.3 to 0.85. In each run, fishing mortality rates for the oldest age group (F_B) were re-evaluated using the iterative procedure. Regressions of F (weighted mean F for fully-recruited fish) on fishing effort, and mean mid-year population biomass on catch per unit effort of fully-recruited fish were used in tuning the analysis to identify an appropriate value for F_T in 1987. Data from 1977 to 1987 were used in the analyses.

Regressions of F on effort produced the highest correlation at $F_T = 0.8$ (Table 7). The residual from the last point (1987) to the regression line was the smallest when $F_T = 0.75$ as were the sum of the residuals or the sum of the squares of the residuals for the past three years (1985-87). The intercept value decreased with increasing F_T but was 0.14 with $F_T = 0.75$.

Regressions of average population biomass on catch per unit of effort were not statistically significant up to $F_T = 0.85$. As a result, regressions of average exploitable biomass for all age groups on catch per unit effort were calculated for the series of terminal fishing mortality values. Average exploitable biomass is calculated by multiplying the average biomass at age in the sequential population analysis (SPA) by the average selectivity coefficients as determined from the fishing mortality matrix. The correlation coefficients increased with increase in the value of F_T with the changing increments indicating a peak slightly beyond 0.85. The residual for the last year (1987) was the smallest when $F_T = 0.80$ while the sum of the residuals or the sum of the squares of the residuals was the least when $F_T = 0.85$ (Table 7). In general, residuals were relatively small for $F_T = 0.65$ and above (Table 7).

In summary, the regression analyses suggest a value of F_T of about 0.75 to 0.85. Estimates derived from the Paloheimo method and catch curves suggest a value of 0.6 while the estimate obtained from tag recaptures was around 0.7 (0.67). These values appear somewhat high but comparable to the average fishing mortality rate for an earlier year with a similar amount of effort (1979 effort = 102, F = 0.749).

Catch projections

Projections were run with F_T varying from 0.65 to 0.8. Recruitment for the projections was estimated from the geometric mean of population numbers for age 6- and 7-year-old fish for the years 1977-85. Weights at age were based on

1984-87 data. Table 8 summarizes the population numbers and fishing mortality rates for the cohort analysis run with $F_T = 0.7$.

Results of the projections are summarized in Table 9. The reference level catch in 1988 ranges from 14 to 17 t with the highest value occurring when $F_T = 0.65$.

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Table 1. Summary of catch and effort statistics for the Voisey assessment unit, 1974-87. Quotas and landings are in kg-round weight, effort is expressed as man-weeks fished.

Year	Quota	Quota[a] area catch	Landings	Effort	CUE
1974			29,180		
1975			3,727		
1976			14,652	57	257
1977			24,108	75	321
1978			36,991	102	363
1979	22,500	21,880	40,590	116	350
1980	22,500	11,557	19,694	82	240
1981	16,100	16,325	23,810	90	265
1982	16,100	2,688	13,309	60	222
1983	16,100	2,953	25,593	80	320
1984	16,100	8,113	20,873	101	207
1985	23,400		15,648	57	275
1986	20,000		16,655	82	203
1987	17,000		21,242	101	210

[a]Quota applied to the Voisey Bay subarea only from 1979 to 1984.

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Table 2. Length-frequency distributions of Voisey assessment unit catches from 1980 to 1987. Mean lengths are also shown.

Fork length interval (cm)	Years								
	1980	1981	1982	1983	1984	1985	1986	1987	Total
42	82	41	16	64	52	4	120	11	390
44	134	43	52	224	277	73	245	89	1,137
46	254	85	107	450	663	331	584	295	2,769
48	384	157	139	562	983	630	804	459	4,118
50	480	238	175	613	1,092	763	958	657	4,976
52	528	337	199	497	933	700	832	602	4,628
54	504	366	161	426	825	562	606	475	3,925
56	323	302	126	289	611	360	419	303	2,733
58	204	199	68	192	418	197	208	145	1,631
60	144	109	47	114	253	104	106	72	949
62	78	74	31	39	136	62	53	35	508
64	48	31	15	26	73	36	25	19	273
Total	3,163	1,982	1,136	3,496	6,316	3,822	4,960	3,162	28,037
Mean length total	53.0	54.4	53.0	51.9	52.7	52.7	51.8	52.5	52.6

Table 3. Summary of likelihood ratio statistics comparing size distribution of commercial Arctic charr catches from the Voisey assessment unit, 1980-87. Time periods 1-4 are defined in the text.

Comparison	G	df	P	N
Years	1,178	77	0.000	28,037
Years:				
Period 1	586	66	0.000	9,358
Period 2	660	77	0.000	11,029
Period 3	286	66	0.000	4,780
Period 4	314	44	0.000	2,870
Time period	1,219	33	0.000	28,037

Table 4. Summary of mean length (cm) of Arctic charr catches by time period for the Voisey, Nain, and Okak assessment units.

	Fork length (cm)		
Time period	Voisey	Nain	Okak
1 - Jun 15-Jul 14	53.7	53.3	53.8
2 - Jul 15-Jul 31	52.3	52.4	52.3
3 - Aug 1-Aug 15	51.8	51.0	51.2
4 - Aug 16-end	51.4	49.7	50.1

Table 5. Estimated catch at age for Arctic charr from the Voisey assessment unit, 1977-1987.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	318	619	475	132	75	255	1841	253	1	41	9
7	2085	4374	4914	666	983	770	2870	2306	2012	797	1397
8	4030	5372	7928	3349	2607	1628	3100	3352	3213	3025	2995
9	2086	2330	3382	4086	4780	2297	4125	2374	3396	3644	4707
10	1237	1236	1163	1341	2350	1140	1790	1577	454	1313	2162
11	600	1141	634	521	941	595	1196	806	336	645	1028
12	389	380	212	260	406	62	801	401	247	229	298
13	212	380	159	166	43	12	68	377	69	140	40
14	108	334	55	64	19	20	8	136	91	111	62
6+	11065	16166	18922	10585	12204	6779	15799	11582	9819	9945	12698
7+	10747	15547	18447	10453	12129	6524	13958	11329	9818	9904	12689
8+	8662	11173	13533	9787	11146	5754	11088	9023	7806	9107	11292
9+	4632	5801	5605	6438	8539	4126	7988	5671	4593	6082	8297

Table 6. Summary of weight (kg round) at age data, partial recruitment rates and calculated $F_{0.1}$ for the Arctic charr population in the Voisey assessment unit.

Age	Weight		Partial recruitment
	1977-79	1984-87	
6	1.53	1.19	0.03
7	1.77	1.39	0.17
8	2.07	1.87	0.44
9	2.60	2.10	1.0
10	2.78	2.39	1.0
11	2.94	2.41	1.0
12	3.24	2.51	1.0
13	3.33	2.28	1.0
14	3.50	1.94	1.0
15	3.46		1.0
16	3.46		1.0

$F_{0.1}$ = 0.40 at a Y/R of 1.08 kg.

Table 7. Results of regressions (1977-87) of F on effort and average exploitable biomass on catch per unit effort for various terminal fishing mortality rates (F_T) for the Voisey assessment unit.

Regression	Parameter	Terminal F 0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85
F (weighted mean for fully- recruited fish) on effort											
	r	0.54	0.57	0.61	0.64	0.67	0.69	0.71	0.72	0.72	0.71
	intercept	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.13
	residual-1987	-0.25	-0.22	-0.18	-0.14	-0.10	-0.06	-0.02	0.02	0.06	0.10
	$\sum$ residuals (1985-87)	-0.46	-0.39	-0.32	-0.26	-0.19	-0.13	-0.07	-0.01	0.05	0.10
	$\sum$ (residuals)^2 (1985-87)	0.10	0.07	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.01
Average exploitable biomass on catch per unit effort											
	r		0.51	0.62	0.69	0.75	0.78	0.81	0.83	0.84	
	intercept (t)		22	18	14	11	8	6	3	2	
	residual-1987 (t)		13	10	7	5	3	2	0	-1	
	$\sum$ residuals (1985-87 (t)		20	16	12	9	6	3	1	-1	
	$\sum$ (residuals)^2 (1985-87) (t)		232	152	101	70	51	41	36	36	

Table 8. Summary of the population numbers and fishing mortality matrix for the cohort analysis run with F_T = 0.70 on the catch at age data for the Voisey assessment unit Arctic charr population.

POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	40386	31399	19100	18544	16212	25805	28208	26565	19579	16792	478
7	21272	32777	25147	15208	15063	13205	20897	21429	21521	16029	13711
8	11633	15530	22878	16143	11849	11443	10115	14512	15458	15799	12402
9	5732	5878	7854	11557	10186	7342	7896	5476	8848	9748	10198
10	3645	2805	2704	3370	5765	4015	3933	2732	2336	4171	4684
11	1597	1865	1178	1162	1546	2594	2255	1600	810	1501	2227
12	1049	765	494	391	480	414	1585	764	581	359	646
13	756	507	282	213	85	25	283	573	263	252	87
14	152	427	71	87	24	31	10	170	128	153	80
6+	86222	91954	79711	66675	61210	64874	75181	73822	69523	64806	44513
7+	45837	60555	60610	48132	44998	39069	46973	47257	49944	48013	44035
8+	24564	27777	35463	32923	29935	25864	26077	25828	28423	31984	30324
9+	12931	12247	12585	16781	18086	14421	15962	11316	12965	16185	17922

FISHING MORTALITY 28/ 1/88

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	0.009	0.022	0.028	0.008	0.005	0.011	0.075	0.011	0.000	0.003	0.021
7	0.115	0.160	0.243	0.050	0.075	0.067	0.165	0.127	0.109	0.057	0.119
8	0.483	0.482	0.483	0.260	0.279	0.171	0.414	0.295	0.261	0.238	0.308
9	0.515	0.576	0.646	0.495	0.731	0.424	0.861	0.652	0.552	0.533	0.700
10	0.470	0.667	0.645	0.579	0.599	0.377	0.699	1.016	0.242	0.427	0.700
11	0.536	1.128	0.903	0.684	1.117	0.292	0.882	0.813	0.614	0.644	0.700
12	0.527	0.796	0.642	1.328	2.736	0.181	0.817	0.867	0.635	1.221	0.700
13	0.371	1.761	0.973	1.977	0.821	0.736	0.309	1.298	0.342	0.951	0.700
14	0.496	0.716	0.674	0.548	0.737	0.379	0.805	0.796	0.490	0.530	0.700
9+	0.497	0.749	0.677	0.564	0.776	0.381	0.810	0.812	0.499	0.538	0.700

Table 9. Summary of projected reference level catch (t) for 1988 and 1989 with F_T in 1987 varying from 0.65 to 0.85.

	F_T in 1987			
	0.65	0.70	0.75	0.80
1988	17.1	16.1	15.1	14.3
1989	19.2	18.4	17.8	17.2

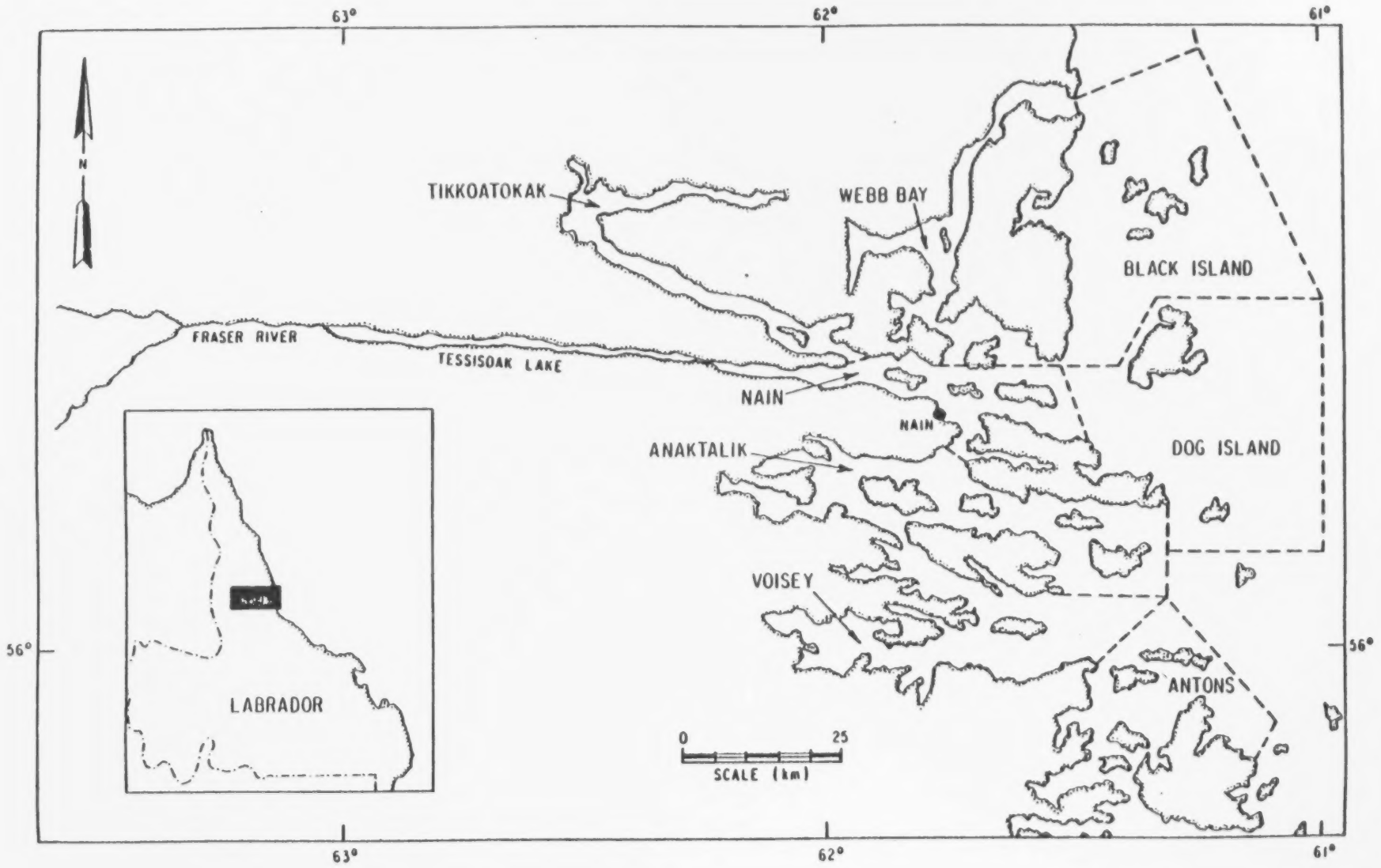

Fig. 1. Location of the Voisey Bay and Antons subareas of the Voisey stock unit.